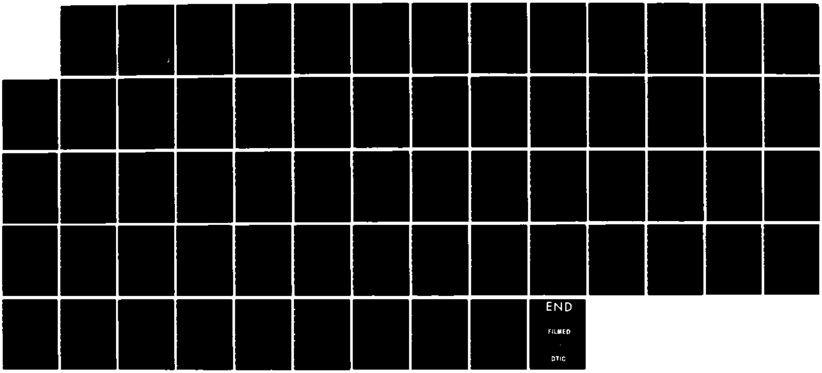
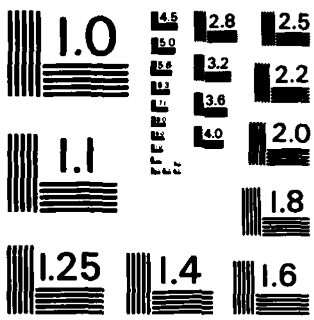
AD-A148 622 RESEARCH IN STOCHASTIC PROCESSES(U) NORTH CAROLINA UNIV AT CHAPEL HILL DEPT OF STATISTICS S CAMBANIS ET AL. OCT 84 AFOSR-TR-84-1080 F49620-82-C-0009 1/1

UNCLASSIFIED F/G 12/1 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

(4)

AD-A148 622

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 84 - 1080
6a. NAME OF PERFORMING ORGANIZATION: University of North Carolina; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Air Force Office of Scientific Research
6c. ADDRESS (City, State and ZIP Code): Statistics Department, Chapel Hill NC 27514	7b. ADDRESS (City, State and ZIP Code): Directorate of Mathematical & Information Sciences, Bolling AFB DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AFOSR; 8b. OFFICE SYMBOL (If applicable): NM	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: F49620-82-C-0009
8c. ADDRESS (City, State and ZIP Code): Bolling AFB DC 20332-6448	10. SOURCE OF FUNDING NOS: PROGRAM ELEMENT NO. 61102F; PROJECT NO. 2304; TASK NO. A5; WORK UNIT NO.

11. TITLE (Include Security Classification): RESEARCH IN STOCHASTIC PROCESSES

12. PERSONAL AUTHOR(S): S. Cambanis, R.J. Carroll, G. Kallianpur, and M.R. Leadbetter

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Interim	FROM 1/11/83 TO 31/8/84	OCT 84	60

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Research was conducted and directed in the area of stochastic processes by three of the principal investigators, S. Cambanis, G. Kallianpur, and M.R. Leadbetter, and their associates, and in statistical estimation and inference by R.J. Carroll and co-workers. A summary of the main lines of activity in each area follows for each of the four principal investigators. More detailed descriptions of the work of all participants is given in the report.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED X SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: MAJ Brian W. Woodruff	22b. TELEPHONE NUMBER (Include Area Code): (202) 767-5027; 22c. OFFICE SYMBOL: NM

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

AFOSR-TR- 84-1080

SCIENTIFIC REPORT

Air Force Office of Scientific Research Grant AFOSR F49620 82 C 0009

Period: 1 November 1983 through 31 August 1984

Title: Research in Stochastic Processes

Co-Principal Investigators: Professor Stamatis Cambanis

Professor Raymond J. Carroll

Professor Gopinath Kallianpur

Professor M. Ross Leadbetter

Department of Statistics

University of North Carolina

Chapel Hill, North Carolina 27514

84 12 05 007

CONTENTS

SUMMARY OF RESEARCH ACTIVITY

Research was conducted and directed in the area of stochastic processes by three of the Principal Investigators, S. Cambanis, G. Kallianpur, and M.R. Leadbetter, and their associates, and in statistical estimation and inference by R.J. Carroll and co-workers. A summary of the main lines of activity in each area follows for each of the four Principal Investigators. More detailed descriptions of the work of all participants is given in the main body of the report.

STOCHASTIC PROCESSES

The research effort in stochastic processes was a major part of a substantial research activity organized as the Center for Stochastic Processes within the Statistics Department, involving permanent faculty, visitors and students. This organization has provided the framework for significant interaction between the participants--permanent and visiting.. In addition the research program has been enhanced by a regular seminar series (listed by speakers later in the report) which has provided an excellent vehicle for exchange of current research ideas. The primary means for dissemination of results is the Center's Technical Reports series, containing current research work prior to formal publication in journals. To date, 80 technical reports leading (or expected to lead) to published papers have been produced by the participants, involving research results in a wide area of stochastic process theory and applications. The main areas of research activity for each Principal Investigator and co-workers are as follows.

S. Cambanis. Non-Gaussian signals: similarities and contrasts between Gaussian and other stable signals; interpolation of harmonizable stable processes; ergodic properties of stationary stable processes; Wold decompositions; moment inequalities for stable integrals; stochastic integral representations of stable processes with paths in Banach spaces; stochastic integrals with respect to independent

increments processes; operator stable distributions. Prediction and modeling of time series: prediction error for small lags; rate of convergence of finite linear predictors; autoregressive representations of multivariate series; doubly stochastic time series models; estimation in nonlinear time series models. Digital processing of analog signals: sampling designs for time series; designs for estimating random integrals from noisy observations; performance of discrete-time predictors of continuous-time processes.

G. Kallianpur Nonlinear filtering theory. Stochastic differential equations. Finitely additive white noise theory: Markov and robustness properties; non-linear prediction and interpolation. Stochastic differential equations in nuclear spaces and application to neurophysiological problems. Stochastic and multiple Wiener integrals. Feynman integrals and abstract Wiener spaces. Non-commutative probability theory. Statistical mechanics: diffusions approximations to the Boltzmann equation. Differential geometry in statistical problems of stochastic processes. Brownian functionals. Stationary processes and prediction theory.

M.R. Leadbetter Extremal theory: extremes and local dependence in stationary sequences; extremes in dependent sequences, continuous stochastic processes, autoregressive processes; estimation of tails of distributions from extreme order statistics. Point processes of exceedances: compound Poisson limit theorems for high level exceedances, point processes describing the joint behavior of order statistics. Estimation for point processes: maximum likelihood estimation in the multiplicative intensity model. Other point process theory: probability generating functionals, waiting time in queues. Estimation and structure for stationary processes: probability density estimation.

<u>R.J. Carroll</u>: Heteroscedasticity: Levene's test for equality of variances, bounded-influence estimation in heteroscedastic models, diagnostics. Binary regression: errors-in-variables models, small measurement errors asymptotics, robust and optimal bounded-influence estimation with extensions to generalized linear models. Transformations in regression: bounded influence estimation, modified likelihood ratio tests. Accelerated life testing: diagnostics for influential points. EM algorithm for censored data: estimating variance in Buckley-James model. Sampling plans: numerical analysis of plans based on prior distributions and costs, variable sampling plans when the normal distribution is truncated. Inventory policies: multi-item inventory problem using optimal policy surfaces.

4

RESEARCH IN STOCHASTIC PROCESSES

STAMATIS CAMBANIS

The work briefly described here was developed in connection with problems arising from and related to the statistical communication theory and the analysis of stochastic signals and systems, and falls into the following three broad categories:

(I) Non-Gaussian signal processing,

(II) Digital processing of analog signals.

Items 1 to 3 below belong to category I. Items 1 and 2 represent continuing work with Drs. Hardin and Weron. Further work in progress on non-Gaussian signals will be reported in the next reporting period; some jointly with Mr. Marques, a Ph.D. student, on discrimination between stable signals and detection of sure signals in stable noise, and some jointly with Dr. Hudson on certain classes of infinitely divisible signals. Items 4 to 6 belong to category II. Item 5 is joint with Dr. Bucklew. Item 6 represents continuing work with Dr. Masry and provided the impetus for further work on sampling designs which will be completed and reported during the next reporting period.

1. <u>Ergodic properties of stationary stable processes</u> [1]

We derive spectral necessary and sufficient conditions for stationary symmetric stable processes to be metrically transitive, mixing, and to satisfy a law of large numbers, and we show how to estimate their covariation functions. We then consider some important special classes of stationary stable processes: Sub-Gaussian stationary processes are never metrically transitive, and we identify their ergodic decomposition. Stationary stable processes with a harmonic spectral representation are never metrically transitive, in sharp contrast with the Gaussian case, and some intriguing facts concerning their ergodic decomposition are derived; also stable processes with a harmonic spectral

representation satisfy a strong law of large numbers even though they are not generally stationary. For doubly stationary stable processes, sufficient conditions are derived for metric transitivity and mixing, and necessary and sufficient conditions for a law of large numbers.

2. <u>Wold decompositions of symmetric stable sequences</u> [2].

This paper introduces a notion of Wold, or orthogonal, decomposition of non-second-order processes and then gives necessary and sufficient conditions for its existence in the case of symmetric stable sequences. The orthogonality used here (the usual orthogonality being inapplicable in the non-second-order case) is known as James' orthogonality -- a non-symmetric notion defined for Banach spaces which is in many ways the most appropriate for our situation.

We show there is an intimate relation between orthogonality of symmetric stable variables. This is exploited to show that a stable sequence has a Wold decomposition if and only if the regression of each random variable on the preceding ones is linear. Also given are conditions for the coincidence of this decomposition with the "non-linear" Wold decomposition (which is shown to always exist), and an equivalent spectral condition for independence in the Wold decomposition.

3. <u>Similarities and contrasts between Gaussian and other stable signals</u> [3].

Gaussian stochastic signals are the simplest and most thoroughly studied among all stable stochastic processes, but are they typical or atypical? Viewed another way, are signal processing techniques designed for Gaussian signals robust with respect to mild departures from normality within the important class of stable stochastic signals? Different answers to this question are given in a variety of contexts such as regression, linear estimation, prediction and

filtering, parameter estimation, signal detection, and system identification. Sharp contrasts as well as certain similarities between Gaussian and other stable processes emerge. Before considering specific problems, stable stochastic signals are introduced and discussed, with particular attention to stationary stable signals. The aim is to survey recent results and to focus attention on open problems.

4. Sampling designs for time series [4].

In practice a time series is observed only at a finite number of points (the sampling design) and based on these observations an estimate or a statistic is formed for use in the problem at hand. The statistician may be free to choose the sampling points, or part of the sampling mechanism may be imposed on the statistician who then controls only certain parameters; e.g. periodic sampling is imposed where the period is controlled by the statistician, or sampling at the times of occurrence of a Poisson stream of events is imposed but the statistician has control over its rate. How can the statistician choose the best design of a given sample size, or determine the sample size of a certain kind of design required to achieve a given performance? These questions are considered in the context of three specific problems involving time series: the estimation of a weighted average of a random quantity, estimation of regression coefficients, and the detection of signals in noise.

The set up here differs in two important ways from the classical set up. All observations are taken from a fixed region and so, especially for large sample sizes, it is not realistic to assume lack of correlation; hence, observations form a correlated time series. Also repeated sampling at the same point is not allowed, and only one realization of the time series is available.

We consider both deterministic and random sampling designs, where either optimal estimators and sufficient statistics are employed, or much simpler

estimators and statistics are employed instead. Finding optimal designs of a given sample size turns out to be a very difficult task, which can be accomplished only for certain specific covariance structures or certain simple sampling designs, such as simple random sampling. Finding sampling designs which for large sample size perform like the best designs, is an easier task, which can be accomplished for broad classes of covariance structures and different designs, such as unconstrained, median and stratified, the latter two in fact using the simpler kind of estimators and statistics. A unified approach is presented here and the results on the simpler estimators of regression coefficients are new.

5. Sampling designs for estimating random integrals with observation noise. [5].

We consider the problem of estimating a weighted average of a random quantity using observations corrupted by noise at a finite number of sampling points, and we study the effect of the observation noise on the sampling design and on its performance. The cases of additive independent noise, of nonlinear distortion plus noise, and of quantization noise are considered in detail.

6. Performance of discrete-time predictors of continuous-time processes [6].

We study the asymptotic performance of linear predictors of continuous-time stationary processes from observations at n sampling instants on a fixed observation interval. We consider both optimal and simpler choices of predictor coefficients; and uniform sampling, as well as nonuniform sampling tailored to the statistics of the process under prediction. We concentrate on stationary processes with rational spectral densities and numerical examples, depicting small sample size performance in addition to asymptotics, are given for cases with no and with one quadratic mean derivative.

References

1. S. Cambanis, C.D. Hardin and A. Weron, Ergodic properties of stationary stable processes, Center for Stochastic Processes Technical Report No. 59, Mar. 84.

2. S. Cambanis, C.D. Hardin and A. Weron, Wold decompositions of symmetric stable sequences, Center for Stochastic Processes Technical Report in preparation.

3. S. Cambanis, Similarities and contrasts between Gaussian and other stable signals, Fifth Aachen Colloquium on Mathematical Methods in Signal Processing, Sept. 26-29, 1984, pp. 113-120.

4. S. Cambanis, Sampling designs for time series, Center for Stochastic Processes Technical Report No. 58, Feb. 1984. Handbook of Statistics, Volume 5: Time Series in Time Domain, E.J. Hannan, P.R. Krishnaiah and M.M. Rao, eds., North Holland, 1984, to appear.

5. J.A. Bucklew and S. Cambanis, Sampling designs for estimating random integrals with observation noise, Center for Stochastic Processes Technical Report in preparation.

6. S. Cambanis and E. Masry, Performance of discrete-time predictors of continuous-time processes, Center for Stochastic Processes Technical Report in preparation.

1. Finitely additive approach to nonlinear filtering (with R.L. Karandikar)[1]

This is the continuation of a project, begun in 1982, of developing a completely new approach to nonlinear filtering theory when the signal and noise are independent. Significant progress was achieved during the period of the present report on the following problems:

(i) The optimal filter in the general white noise model is shown to be a Markov process. More precisely, it is shown that $F_t(y)$ and $\Gamma_t(y)$ - the normalized and unnormalized conditional distribution (where y is the white noise observation) regards as measure-valued processes either on the quasi-cylindrical probability space $(E,\mathcal{E},\alpha)$ or as defined on $(H,\mathcal{C},n)$ are Markov processes. (For definitions and details, see Technical Report No. 44. [2])

The principal difficulty until now has been the lack of a suitable transformation formula. The question is solved by paying more attention to the underlying theory, by discovering a more versatile definition of conditional expectation (See Section 2).

(ii) Robustness results: A crucial achievement of the white noise theory is its robustness properties. Some of the results were reported in [8] but the best were proved with the aid of the stronger theory worked out in [3] and are included there. In addition to robustness, the consistency of the finitely additive filtering approach with the conventional theory based on martingale calculus and Ito stochastic differential equations have been established. A typical result may be briefly stated as follows: Let $y_s = h_s(X_s) + e_s$, $0 \leq s \leq T$ be the finitely additive filtering model defined on the quasi-cylindrical probability space $(E,\mathcal{E},\alpha) = (\Omega,\mathcal{A},\Pi) \otimes (H,\mathcal{C},m)$ where e is Gaussian white noise, $H = L^2[0,T]$ and (X_s) is the $\mathbb{R}^d$-valued

signal process defined on (Ω, A, Π). The stochastic calculus model is $Y_t = \int_0^t h_s(X_s)ds + W_t$, (W_t) being a standard Wiener process. Let $p_t(x,\eta)$ be the unnormalized conditional density of X_t given y, obtained as the unique solution of the finitely additive Zakai equation. Then (a) there exists a continuous function

$$\hat{p}\,(\cdot, Z):\ C_0([0,T];\mathbb{R}^m) \to C([0,T]\times\mathbb{R}^d)$$

such that for all $\eta \in H$,

$$\hat{p}_t(x,Z) = p_t(x,\eta)\ ,\quad 0 \leq t \leq T,\ x \in \mathbb{R}^d \quad \text{where}\ \ Z_t = \int_0^t \eta_s ds\cdot\ ;$$

(b) $\hat{p}_t(x,Y)$ is a version of the unnormalized conditional density of X_t are given F_t^Y.

The precise conditions under which the above theorem is proved are given in [2]. The result shows that the robustness results of the stochastic calculus approach (e.g. the results of Pardoux) can be obtained more simply from the white noise theory under slightly weaker conditions.

2. <u>White noise calculus</u> (with R.L. Karandikar)

A full-fledged development of the theory behind the new approach to nonlinear filtering theory (described in Sec. 1) was undertaken in [3] which is a first draft of a forthcoming monograph. The authors introduce integration with respect to a quasi-cylinder probability measure (QCP) of suitable classes of cylinder functions, followed by a definition of absolute continuity of QCP's. Although the notions of a representation and lifting associated with a QCP are similar to ideas of I.E. Segal and L. Gross, the problems of nonlinear filtering are sufficiently different as to require a detailed and independent treatment. Another most useful and important concept is that of a quasi-cylindrical mapping (QCM) which has most of the desirable properties of a random variable in the countably additive theory. A QCM defined on a

quasi cylindrical probability space induces a QCP on the range space and an associated induced representation. Furthermore it yields a definition of conditional expectation more inclusive and useful than the one to be found in an earlier paper of ours.

3. Feynman integrals (with D. Kannan and R.L. Karandikar) [4]

Reported under Karandikar's work.

4. Application of differential geometry in statistical problems of stochastic processes (with H.H. Kuo) [5]

Reported under Kuo's work.

5. Regularity property of Donsker's delta functional (with H.H. Kuo) [6]

Reported under Kuo's work.

6. Stochastic differential equation models for neuronal behavior (with R. Wolpert, Duke University). [7]

This is a continuation of earlier work (described in the last report) in which changes in the voltage potential of a spatially distributed neuron was treated as a stochastic process taking values in a suitable nuclear space. A nuclear space-valued Ornstein-Uhlenbeck process was obtained as a diffusion approximation. In the present work, see [7] more realistic models are considered (under the mathematically simplifying assumption that the spatial extension of the neuron is neglected) which take into account such nonlinear phenomena as reversal potentials, or the situation when the sizes of the postsynaptic impulses depend on the state of depolarization of the membrane potential. Non-gaussian diffusion approximations to neuronal behavior are obtained. As a special case we obtain the diffusion approximation to the Wan-Tuckwell equation with reversal potentials. The latter problem leads to an interesting investigation

of boundary behavior.

The next phase of the work is to extend the above theory to spatially distributed neurons. Also on the agenda is a satisfactory description, from the stochastic point of view, of the celebrated Hodgkin-Huxley equations.

Ph.D. students under Gopinath Kallianpur

Victor Perez-Abreu: Research on his Ph.D. thesis is on the following topics:

(1) Product stochastic measures: A new approach to product stochastic measures has been developed which systematically exploits the use of symmetric tensor product Hilbert spaces. Comparison with Engel's work is discussed and other examples are considered.

(2) Multiple Wiener integrals for nuclear space valued-processes:

Multiple Wiener integral expansions and stochastic integral representations have been obtained.

Soren Christensen: Stochastic Differential Equations for nuclear space-valued processes and applications. Research on his Ph.D. thesis is on extensions and generalizations of Kallianpur and Wolpert's work on stochastic differential equation models for spatially distributed neurons. The case of a semigroup (T_t) which is not necessarily Hilbert-Schmidt is considered. Weak convergence to diffusion approximations (under various conditions) is being investigated.

Hans Hucke: Nonlinear prediction and interpolation problems: Hucke is extending the (finitely additive) white noise theory of Kallianpur and Karandikar with a view of applying it to nonlinear prediction and smoothing problems. General signal processes will be considered. He will also investigate robustness properties for these problems and hopes to obtain results similar to those derived for nonlinear filtering theory.

References

1. G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering: A brief survey, Center for Stochastic Processes Technical Report No. 42, Nov. 1983. Proc. 6th Int. Symp. on Multivariate Anal., 1984, to appear.

2. G. Kallianpur and R.L. Karandikar, The Markov property of the filter in the finitely additive white noise approach to nonlinear filtering, Center for Stochastic Processes Technical Report No. 44, Nov. 1983.
To appear in Stochastics.

3. G. Kallianpur and R.L. Karandikar, White noise calculus and nonlinear filtering theory, Center for Stochastic Processes Technical Report No. 67, June 1984.

4. G. Kallianpur, D. Kannan, and R.L. Karandikar, Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces, and a Cameron-Martin formula, Center for Stochastic Processes Technical Report No. 53, Dec. 1983.

5. G. Kallianpur and H.H. Kuo, Applications of differential geometry in statistical problems of stochastic processes, Center for Stochastic Processes Technical Report in preparation.

6. G. Kallianpur and H.H. Kuo, Regularity property of Donsker's delta function, Center for Stochastic Processes Technical Report No. 51, Dec. 1983. Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and their Applications, 1984, to appear in Jour. Applied Math. and Optimization.

7. G. Kallianpur and R. Wolpert, Weak convergence of solutions of stochastic differential equations with applications to nonlinear neuronal models, Center for Stochastic Processes Technical Report No. 60, March 1984.

8. G. Kallianpur and R.L. Karandikar, Some recent developments in nonlinear filtering theory, Center for Stochastic Processes Technical Report No. 38, July 1983. Acta Appl. Math., 1, 1984, 249-284.

M.R. LEADBETTER

During this reporting period, research was continued or initiated in the following main areas: (1) continued effort in the theory of point processes associated with extremal theory for stochastic sequences (2) extremal theory for non-stationary sequences, (3) further development of extremal theory in continuous time and (4) function estimation for stationary processes. The effort in each is described below.

(1) Point processes associated with extremal theory.

Work continued with J. Hüsler and T. Hsing on the detailed structure of the point process of high level upcrossings, extending the results previously reported in [1]. Two different approaches give related results. One of these, described in the report [2], gives sufficient conditions for convergence of the exceedance point processes to a compound Poisson process. The other, involving a direct "Laplace Transform" approach, yields a complete characterization of the limiting point process, under natural conditions. This work is to be reported in [3].

Extensive work has been done also into so called "complete convergence" results involving the point process consisting of the values of a stochastic sequence plotted (with appropriate normalizations) in the plane. Such results give a comprehensive picture of the extremal properties of the sequence - including the joint asymptotic distributional behavior of the maximum and other extreme order statistics. A theory generalizing that of Mori [4] has been obtained, in which the possible limiting point processes are fully characterized. This has been partially reported in [5], and further report and journal publication is planned.

(2) Extremal theory for non-stationary sequences

Presently available extremal results for non-stationary sequences have typically been obtained by generalizing those for stationary cases in relatively restricted and obvious ways. An investigation has begun taking a more systematic approach, first considering classes of normal non-stationary processes with rather general correlation structure. It is planned that some of these results will be included in [6] together with results of H. Rootzén on Markov sequences.

(3) Extremal theory in continuous time.

A rather satisfying theory for extremes of continuous parameter stationary processes has been developed in recent years and reported e.g. in the book [7]. Some attention has been given in the current reporting period towards extending this theory to cases of higher local dependence. In particular this involves the attempt to parallel the discrete time theory of high level exceedances (cf. (1) above) for high level upcrossings in continuous time. However, there are also features which appear in continuous time which have no interesting analogue in the discrete context (due to the presence of arbitrarily high correlation at close time points). These are being investigated - considerable work remains to be done to obtain definitive results.

(4) Function estimation for stationary processes.

The research on this topic described in the previous report has been further developed in the current period. This has resulted in a fairly comprehensive account of consistency and asymptotic distributional properties of smoothed estimates of the probability density of a stationary sequence or continuous parameter process. This work (with J. Castellana) has been reported in [8] and submitted to J. Stoch. Proc. for publication.

References

1. M.R. Leadbetter, Extremes and local dependence in stationary sequences, Center for Stochastic Processes Technical Report No. 12, June 1982. Zeit. f. Wahr. verw. Geb., 1984, 291-306.

2. J. Hüsler, Local dependence and point processes of exceedances in stationary sequences, Center for Stochastic Processes Technical Report No. 77, Sept. 1984.

3. T. Hsing and M.R. Leadbetter, Limit theorems for high level exceedances by stationary sequences, Center for Stochastic Processes Technical Report in preparation.

4. T. Mori, Limit distributions of two dimensional point processes generated by strongly mixing sequences, Yokohama Math J. 25, 155-167, 1977.

5. T. Hsing, Point processes associated with extremes of stochastic sequences, Ph.D. dissertation, Statistics Dept., Univ. of N.C. 1984.

6. M.R. Leadbetter and H. Rootzén, Extremal theory - a point process approach, special invited paper for Ann. Prob. in preparation.

7. M.R. Leadbetter, G. Lindgren and H. Rootzén, Extremes and related properties of random sequences and processes, Springer Statistics Series, 1983.

8. J. Castellana and M.R. Leadbetter, On smoothed probability density estimation for stationary sequences, Center for Stochastic Processes Technical Report No. 50, Submitted to J. Stoch. Proc.

JAMES A. BUCKLEW

Dr. Bucklew completed the work described in the following reports.

1. The prediction error for small time lags into the future [1].

Explicit expressions are derived for the derivatives at zero lag of the mean square prediction error of a class of stationary processes, which includes those with rational spectral density. A sufficient condition on the spectral density is given for a stationary process to belong to this class, and it is shown that the stationary process with triangular covariance does not belong to the class.

2. Sampling designs for estimating random integrals with observation noise [2].

We consider the problem of estimating a weighted average of a random quantity using observations corrupted by noise at a finite number of sampling points, and we study the effect of the observation noise on the sampling design and on its performance. The cases of additive independent noise, of nonlinear distortion plus noise, and of quantization noise are considered in detail.

References

1. J.A. Bucklew, A note on the prediction error for small time lags into the future, Center for Stochastic Processes Technical Report No. 78, Sept. 1984.

2. J.A. Bucklew and S. Cambanis, Sampling designs for estimating random integrals with observation noise, Center for Stochastic Processes Technical Report in preparation.

D.J. DALEY

Dr. Daley conducted research in the theory of queues and point processes. This work is reported in [1] and [2], whose abstracts are as follows:

1. <u>A lower bound for mean characteristics in $E_k/G/1$ and $GI/E_k/1$ queues</u> [1].

The mean stationary waiting time EW of a stable $E_k/G/1$ queuing system depends on the service distribution through its first two moments and k-1 roots of an equation involving its transform. Vainshtein's (1983) work on delimiting the region where such roots lie is improved and leads to a bound on EW that is always tighter than other known lower bounds. The methods can also be applied to $GI/E_k/1$ systems, but the bounds are not as tight.

2. <u>On the probability generating functional for point processes</u> [2].

An extended probability generating functional (p.g.fl.) G is defined for a point process N on a complete separable metric space. The distribution of N is uniquely determined by G over a small class of functions. Continuity results are reviewed and used in furnishing a complete p.g.fl. proof of the mixing properties of certain stationary cluster processes.

References

1. D.J. Daley, A lower bound for mean characteristics in $E_k/G/1$ and $GI/E_k/1$ queues, Center for Stochastic Processes Technical Report no. 62, May 1984.

2. D.J. Daley and D. Vere Jones, On the probability generating functional for point processes, Center for Stochastic Processes Technical Report No. 76, Sept. 1984.

RICHARD A. DAVIS

Dr. Davis, in joint work with Resnick, investigated the problem of estimating the tail of a distribution function using extreme order statistics. The approach assumes one knows only that the unknown distribution is in some domain of attraction of an extreme value distribution. The results of this study are contained in the paper [1] which will appear December 1984 in the Annals of Statistics.

Davis and Resnick considered the large sample behavior of the sample covariance and correlation functions of the moving average $X_t = \sum_{j=-\infty}^{\infty} c_j Z_{t-j}$ where $\{Z_t\}$ is iid with common distribution in the domain of attraction of a stable law with index α, $0 < \alpha < 2$. If $0 < \alpha < 2$, $E|Z_1|^\alpha < \infty$ and the distribution of $|Z_1|$ and $|Z_1 Z_2|$ are tail equivalent, then the sample correlation function of $\{X_t\}$ suitably normalized converges in distribution to the ratio of two dependent stable random variables. On the other hand if $E|Z_1|^\alpha = \infty$, the limit distribution is the ratio of two independent stable variables. The derivations of these results rely heavily on point process techniques. In the $\alpha = 2$ case, the sample correlations are shown to be asymptotically normal which extends the classical result. These results are written up in the papers [2] and [3].

Davis and Yao considered the problem of testing a shift in mean in a sequence of independent normal random variables in the paper [4]. The asymptotic operating characteristics of the likelihood ratio test in testing H_0 (no change point) vs. H_1 (change point) were derived. It was shown that the asymptotic null distribution is closely related to the extreme value of the Ornstein-Uhlenbeck process and converges in distribution to the double exponential extreme value distribution.

References

1. R. Davis and S. Resnick, Tail estimates motivated by extreme value theory, Center for Stochastic Processes Technical Report No. 54, Jan. 84, Ann. Statistics, 12 , 1984, to appear.

2. R. Davis and S. Resnick, Limit theory for the sample covariance and correlation functions of moving averages, Center for Stochastic Processes Technical Report No. 68, July 1984.

3. R. Davis and S. Resnick, More limit theory for the sample correlation function of moving averages, Center for Stochastic Processes Technical Report No. 72, Aug. 1984.

4. Y.C. Yao and R.A. Davis, The asymptotic behavior of the likelihood ratio statistic for testing a shift in mean in a sequence of independent normal variates, Center for Stochastic Processes Technical Report No. 81, Sept. 1984.

LAURENS de HAAN

Dr. de Haan conducted research in extremal and related theory, with particular reference to relationships between the operations of "maximum" and "sum". This work is reported in [1] which discusses stationary processes that are max-autoregressive in one time direction and sum-autoregressive in the other.

References

1. L. de Haan, Renyi's representation, extremal processes and an autoregressive process, Center for Stochastic Processes Technical Report No. 66, June 1984.

TADAHISA FUNAKI

Diffusion approximations to the Boltzmann equation [1,2].

Dr. Funaki has continued his work on problems of statistical mechanics, specifically, the study of the Boltzmann equation. A jump process is associated with the spatially homogeneous Boltzmann equation by solving a martingale problem. With suitable scaling, this process is shown to converge weakly to a stochastic process related to a nonlinear diffusion equation known as the Landau equation.

In a similar context, existence and uniqueness theorems have been obtained for the martingale problem associating diffusion processes with a type of nonlinear parabolic equation.

References

1. T. Funaki, A certain class of diffusion processes associated with nonlinear parabolic equations, Center for Stochastic Processes Technical Report No. 43, Nov. 1983.

2. T. Funaki, The diffusion approximation of the spatially homogeneous Boltzmann equation, Center for Stochastic Processes Technical Report No. 52, Dec. 1983.

WILLIAM N. HUDSON

Dr. Hudson continued his work on multivariate operator stable distributions and initiated the study of stochastic integrals with respect to general independent increments processes.

1. <u>The symmetry group and exponents of operator stable probability distributions</u> [1].

It is shown that there exist exponents of an operator stable distribution which commute with every operator in the distribution's symmetry group. These exponents, together with a new norm, lead to useful simplifications in the representation of the distribution's Lévy measure.

3. <u>Stochastic Integrals with Respect to Independent Increment Processes</u> [2].

The stochastic integral $\int_0^t V(s)d\zeta(s)$ is defined, where ζ is a stochastically continuous process with independent, but not necessary stationary, increments, without a Gaussian component, and which is adapted to a filtration, and V is a stochastic process which is adapted to the same filtration. If the paths of ζ are not of bounded variation over $[0,t]$, the integrands V are assumed to be predictable and to satisfy the condition

$$\int_{[-\alpha,\alpha]\times[0,t]} \{(xV(s))^2 \wedge |xV(s)|\}dM(x,s) < \infty \qquad \text{a.s.}$$

for some $\alpha > 0$ where M denotes the jump-time Lévy measure of ζ. This class is larger than that produced by the usual martingale approach and was first used by Kallenberg [4] who assumed ζ had stationary increments.

The results concerning approximation of integrands by simple processes and the existence of the integral contain new features. An elementary method is used to obtain simple processes which approximate the integrands. An argument of Kallenberg is extended to show the existence of this integral. This

stochastic integral is also shown to be indistinguishable from the pathwise Lebesgue-Stieltjes integral whenever both integrals exist. The integral is shown to possess the usual properties and a complex-valued exponential martingale is associated with the integral.

Finally, attention is focused to nonrandom integrands, and a formula is obtained for their characteristic function. The class of integrands turns out to be as large as possible consistent with this formula, which provides an easy way to show that such integrals are themselves stochastic processes with independent increments. The jump-time Lévy measure is easily obtained and used to show that if V_1 and V_2 are two integrable processes, then $\int_0^t V_1 d\zeta$ and $\int_0^t V_2 d\zeta$ are independent random variables if and only if $V_1(s)V_2(s)=0$ μ-a.e. where $\mu(A) = \int_{R\times A} (x^2 \wedge 1)dM(x,s)$.

References

1. W.N. Hudson, Z.J. Jurek and J.A. Veeh, The symmetry group and exponents of operator stable probability measures, Center for Stochastic Processes Technical Report No. 72, August 1984.

2. W.N. Hudson, Stochastic integrals with respect to independent increment processes, Center for Stochastic Processes Technical Report, in preparation.

3. O. Kallenberg, On the existence and path properties of stochastic integrals, Ann. Probability 3, 1975, 262-280.

RYSZARD JAJTE

Strong limit theorems in von Neumann algebras. [1]

Several classical pointwise convergence theorems have been extended to the context of von Neumann algebras. The dynamics of a quantum mechanical system S (described by a von Neumann algebra A and a state ϕ) are given by a one parameter group (α_t) of automorphisms of A. It is of great interest to know the asymptotic behavior of the ergodic averages

$$(*) \quad \frac{1}{n} \sum_{k=0}^{n-1} \alpha^k(x) \qquad (n=1,2\ldots) \text{ as } n \to \infty$$

for $x \in A$. Theorems related to this problem are proved.

References

1. R. Jajte, A non-commutative quasi subadditive ergodic theorem, Center for Stochastic Processes Technical Report No. 73., August 1984.

RAJEEVA L. KARANDIKAR

1. Finitely additive approach to nonlinear filtering theory [1] (with G. Kallianpur): Reported under Kallianpur's work.

2. White noise calculus [2] (with G. Kallianpur): Reported under Kallianpur's work.

3. Feynman integrals [3] (with G. Kallianpur and D. Kannan).

Continuing earlier work on this subject, a unified approach is presented: Sequential Feynman integrals are defined for classes of functions on Hilbert space and on an abstract Wiener space. A Cameron-Martin formula is proved for analytic and sequential Feynman integrals for the classes $G^q(B)$ and $G^q(H)$. A function g on H belongs to $G^q(H)$ if it is of the form

$$g(h) = e^{i/2(h,Ah)} \int e^{i(k,h)} du(k) \qquad \text{where } q\ (\neq 0) \text{ is a real number,}$$

μ is a complex, bounded Borel measure on H and A is a self-adjoint, trace class operator on H such that $I + \frac{1}{q} A$ has a bounded inverse. The class $G^q(B)$ has an analogous definition.

4. Limiting distributions of functionals of Markov chains. (with V.G. Kulkarni)

If X_n is a Markov chain with stationary transition probabilities and $Y_n = f(X_n,\ldots,X_{n+k})$ (k fixed) then Y_n depends on X_n in a stationary way in the sense that $P(Y_n \in A|X_n)$ does not depend on n. Sufficient conditions for Y_n to have a limiting distribution are derived for the following two cases: (i) $\{X_n, n \geq 0\}$ has a limiting distribution, (ii) $\{X_n, n \geq 0\}$ does not have a limiting distribution and exits every finite set with probability one. Several examples are considered including that of a nonhomogeneous Poisson process with periodic rate function for which the limiting distribution of the inter-event times is obtained.

References

1. G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering: A brief survey, Center for Stochastic Processes Technical Report No. 42, Nov. 1983. Proc. 6th Int. Symp. on Multivariate Anal., 1984, to appear.

2. G. Kallianpur and R.L. Karandikar, White Noise calculus and nonlinear filtering theory, Center for Stochastic Processes Technical Report No. 67, June 1984.

3. G. Kallianpur, D. Kannan, and R.L. Karandikar, Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces, and a Cameron-Martin formula, Center for Stochastic Processes Technical Report No. 53, Dec. 1983, to appear.

4. R.L. Karandikar and V.G. Kulkarni, Limiting distributions of functionals of Markov chains, Center for Stochastic Processes Technical Report No. 74, August 1984.

ALAN F. KARR

Dr. Karr pursued various research topics in the general area of statistical inference for stochastic point processes. He completed the technical report [1], which has been accepted for publication in the Annals of Statistics. Further work dealt with strong approximation of Poisson processes, inference for Poisson processes with one observable comment and inference for point processes given integral data. Karr also completed Chapters 3-8 of his forthcoming book Point Processes and their Statistical Inference.

References

[1] A. Karr, Maximum likelihood estimation in the multiplicative intensity model, Center for Stochastic Processes Technical Report No. 46, Nov. 83.

AHMET HAYRI KOREZLIOGLU

1. Stochastic integration for operator-valued processes on Hilbert spaces and on nuclear spaces. [1] (with C. Martias).

The aim of the work is to give a representation of distribution-valued square-integrable martingales by means of stochastic integrals with respect to a given distribution-valued martingale. The problem of representation of Hilbert-space valued martingales is reconsidered so as to include stochastic integration of Hilbert-Schmidt operator valued processes.

2. An approximation for the Zakai equation by a finite difference equation [2].

Consider the filtering problem,

$$X_t = X_0 + \int_0^t a(X_s)ds + \int_0^t b(X_s)dB_s \,,$$
$$Y_t = \int_0^t c(X_s)ds + W_t$$

where X_0, B and W are independent, B and W being one dimensional Wiener processes and X_0 is real. An approximate computation procedure (at periodic sampling points $t = nh$, $n \in \mathbb{N}$, $h > 0$) of the unnormalized conditional measure σ_t of the Zakai equation is proposed. It is shown that $E|\sigma_{nh}(f) - \sigma'_{nh}(f)| \to 0$ as $n \to \infty$ for $t = nh$ and the speed of convergence is $O(n^{-1/2})$. (Here f is a sufficiently regular function and σ' is the solution of the approximating recursive equation).

References

1. H. Korezlioglu and C. Martias, Stochastic integration for operator-valued processes on Hilbert spaces and on nuclear spaces, Center for Stochastic Processes Technical Report in preparation.

2. H. Korezlioglu, An approximation for the Zakai equation by a finite difference equation, Center for Stochastic Processes Technical Report in preparation.

HUI-HSIUNG KUO

1. Applications of differential geometry in statistical problems of stochastic processes [1] (jointly with G. Kallianpur).

This work is motivated by the recent paper of Amari [Ann. of Statist. 8, 1980] on the use of differential geometric techniques in (finite-dimensional) parameter estimation in statistics.

With the idea of extending the elegent approach of Amari and Efron to stochastic processes, we study the concepts of Riemmanian connection, Christoffel symbols, curvature and geodesics, "curved" families of measures, etc., for Riemmanian Hilbert manifolds. The reason for considering Hilbert manifolds is that the natural parameters in inference in stochastic processes are infinite dimensional manifolds. A preliminary investigation has been made, largely consisting of gathering known facts on Hilbert manifolds. We have written up a unified account of that part of Amari's work that is dimension free and have tried to formulate the statistical problems in stochastic processes to which these concepts are to be applied. The part already done is being prepared as a Technical Report. Further work will be carried out later.

2. On generalized Brownian functionals [2] (jointly with G. Kallianpur)

The regularity property of Donsker's delta function $\delta(B(t)-x)$ is established. The result is applied to obtain a simple proof of Ito's lemma for $f(B(t))$ where f is a tempered distribution.

References

1. G. Kallianpur and H.H. Kuo, Applications of differential geometry in statistical problems of stochastic processes, Center for Stochastic Processes Technical Report in preparation.

2. G. Kallianpur and H.H. Kuo, Regularity property of Donsker's delta function, Center for Stochastic Processes Technical Report No. 51, Dec. 1983. Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and their Applications, 1984, to appear in Jour. Applied Mathematics and Optimization, 1984.

HANNU O. NIEMI

Prediction properties of stationary random fields on $\mathbb{Z}^2$ [1].

Let $X_{m,n}$, $(m,n) \in \mathbb{Z}^2$, be a second order stationary random field with spectral measure ν_X. The work is devoted to establishing the relationship between the spectral representation of the random field and the four-fold Wold decomposition for $X_{m,n}$ obtained by Kallianpur and Mandrekar (Prediction Theory and Harmonic Analysis, V. Mandrekar and H. Salehi, eds., North Holland, 1983, 165-190.) The differences between the two Wold-Halmos decompositions (Theorems 1.1 and 1.2) of the cited paper have been expressed in spectral terms. A spectral characterization of the horizontal (resp. vertical) Wold decomposition for $X_{m,n}$ has also been obtained, clarifying earlier results by Chiang-Tse Pei (Theor. Probability Appl. 2, 1957).

References

1. H.O. Niemi, Prediction properties of stationary random fields on $\mathbb{Z}^2$, Center for Stochastic Processes Technical Report in preparation.

MOHSEN POURAHMADI

Dr. Pourahmadi continued his work on prediction of multivariate stationary processes and also worked on prediction problems for stable processes and on nonlinear time series models.

1. <u>On Minimality and Interpolation of Harmonizable Stable Processes</u> [1]

It is shown that a harmonizable symmetric α-stable process, i.e. the Fourier coefficients of a process with independent symmetric α-stable increments, with spectral density w is minimal, if and only if w>0 a.e. and $w^{-1/(\alpha-1)}$ is integrable. Algorithms for the linear interpolator and interpolation error of such processes are given when several values of the process are missing. The algorithm for the linear interpolator is convergent if w satisfies Muchenhoupt's (A_α) condition.

2. <u>On Stationarity of the Solution of a Doubly Stochastic Model</u> [2].

Consider the discrete parameter process $\{X_t\}$ satisfying the doubly stochastic model $X_t = \phi_t X_{t-1} + \varepsilon_t$, where $\{\phi_t\}$ and $\{\varepsilon_t\}$ are also stochastic processes. Necessary and sufficient conditions on $\{\phi_t\}$ are given for $\{X_t\}$ to be a second order process. When $\{\phi_t\}$ is a strictly stationary process, some sufficient conditions in terms of $\{\phi_t\}$ are given which guarantee the wide sense stationarity of $\{X_t\}$. It turns out that for these problems the distribution and dependence structure of the process $\{\log|\phi_t|\}$ play an important role.

3. <u>On the Rate of Mean Convergence of Finite Linear Predictors of Multivariate Stationary Stochastic Processes</u> [3]

Consider a multivariate weakly stationary stochastic process $\{X_n\}$ with the spectral density matrix f satisfying the boundedness condition. It is shown that if the entries of f are analytic functions of θ on $[-\pi,\pi]$, then the rates of

convergence of the one-step ahead linear least squares predictor of $\{X_n\}$ based on a finite segment of the past, and of the partial sum of the infintie linear least squares predictor of the process to the Kolmogorov-Wiener predictor, are at least exponential.

4. Infinite Order Autoregressive Representations of Multivariate Stationary Stochastic Processes [4]

Consider a q-variate weakly stationary stochastic process $\{X_n\}$ with the spectral density W. The problem of autoregressive representation of $\{X_n\}$ or equivalently the autogreressive representation of the linear least squares predictor of X_n based on the infinite past is studied. It is shown that for every W in a large class of densities, the corresponding process has a mean convergent autoregressive representation. This class includes as special sub-classes, the densities studied by Masani (1960) and the author (1984). As a consequence it is shown that the condition of integrability of W^{-1} or minimality of $\{X_n\}$ is dispensable for this problem. When W is not in this class or when W has zeros of order 2 or more, it is shown that in this case $\{X_n\}$ has a mean Abel summable or mean compounded Césaro summable autoregressive representation.

References

1. M. Pourahmadi, On minimality and interpolation of harmonizable stable processes, Siam J. Appl. Math., 44, 1984, 1023-1030.

2. M. Pourahmadi, On stationarity of the solution of a doubly stochastic model, Center for Stochastic Processes Technical Report No. 61, April 1984.

3. M. Pourahmadi, On the rate of mean convergence of finite linear predictors of multivariate stationary stochastic processes, Center for Stochastic Processes Technical Report No. 69, July 1984.

4. M. Pourahmadi, Infinite order autoregressive representations of multivariate stationary stochastic processes, Center for Stochastic Processes Technical Report No. 75, September 1984.

HOLGER ROOTZÉN

Dr. Rootzén completed his research with J. Sternby on a Bayesian approach to consistency in least squares estimation (cf. abstract in 1983 report). This work has now been published ([1]).

In the area of extreme values, Dr. Rootzen considered the greatest possible rates of convergence of the (normalized) maximum to an extreme value distribution, for i.i.d. sequences. He showed that the difference between this distribution of the maximum and its limit, could not tend to zero at "arbitrary *exponential* rates", unless the distribution of the terms of the sequence is itself of extreme value type. However, examples show that any specific exponential rate is attainable by some sequence having a non-extreme value distribution. This work has been reported in the publication [2].

References

1. H. Rootzén and J. Sternby, Consistency in least squares estimation: a Bayesian approach, Center for Stochastic Processes Technical Report No. 48, Nov. 1983. Automatica,20, 1984, 471-475.

2. H. Rootzén, Attainable rates of convergence of maxima, Statistics and Probability Letters, 2, 1984, 219-221.

JAN ROSINSKI

Dr. Rosinski is pursuing his work on stable processes and measures.

1. Stochastic integral representation of stable processes with sample paths in Banach spaces. [1]

A symmetric stable process, $X(t)$, $t \in T$, can be represented as a stochastic integral $\int_0^1 f(t,s)dM(s)$, $t \in T$, where M is a stable motion, and a fundamental problem is to relate properties of the process X with properties of the kernel f. Here, we assume that the sample paths of the process X belong to a certain Banach space V(T) of functions on T. We show that the kernel f can be modified in such a way that its sections $f(\cdot,s)$ belong to the same Banach space V(T) (the converse is false in most interesting cases). This enables us to use some techniques of probabilities on Banach spaces to estimate the moments of the norm of the sample paths of the process: $||X(\cdot)||_{V(T)}$. Applying this result we solve the problem of estimation of the moments of a double integral of stable motion. We also characterize infinitely divisible distributions whose tail behaviour is similar to the tail behaviour of stable distributions. This permits us to extend previous results to a more general class of distributions, including in particular all semistable distributions; and also to establish the equivalence of the moments of processes with stochastic integral representations in terms of motions determined by these more general distributions, with the corresponding moments of stable processes.

2. Moment inequalities for p-stable stochastic integrals [2].

We apply the inner clock device to estimate the moments of Itô-type stochastic integrals $\int_0^t F(s,\omega)dM(s,\omega)$ with respect to p-stable motion M, in terms of the

moments of the random scale change $\tau(t,\omega) = \int_0^t |F(s,\omega)|^p ds$. We also generalize and apply a result of Bass and Cranston (Ann. Probability, 11, 1983, 578-588) concerning moments of exit times and exit points for symmetric stable processes.

3. Continuity of some random integral mappings [3].

Jurek and Vervaat (Z. Wahr., 62, 1983, 247-262) proved that every selfdecomposable measure μ on a Banach space B is the distribution of the stochastic integral $\int_0^\infty e^{-t}dX(t)$, where the Banach space valued process X has stationary independent increments and $E \log_+||X(1)|| < \infty$. Moreover, the mapping which takes the law of X(1) to the law of $\int_0^\infty e^{-t}dX(t)$ is an algebraic isomorphism of the convolution semigroup $ID_{\log}(B)$ of all infinitely divisible μ's with $\int \log_+||x||d\mu(x) < \infty$ and the Lévy class L(B). In this paper we solve the problem of the continuity of this isomorphism. We find a metric topology of $ID_{\log}(B)$ such that this mapping becomes a topological isomorphism. This enables us to determine generators of the Lévy class L(B). These results are also generalized to the class of operator selfdecomposable measures. We also study, as a necessary tool, the relationship between the uniform integrability of infinitely divisible probability measures and of their Lévy measures, which may be of independent interest.

References

1. J. Rosinski, Stochastic integral representation of stable processes with sample paths in Banach spaces, Center for Stochastic Processes Technical Report in preparation.

2. J. Rosinski and W.A. Woyczynski, Moment inequalities for p-stable stochastic integrals, Center for Stochastic Processes Technical Report in preparation. To appear in Proc. 5th International Conference on Probability in Banach Spaces, Medford, July 1984, Lecture Notes in Mathematics, Springer.

3. Z. Jurek and J. Rosinski, Continuity of some random integral mappings, Center for Stochastic Processes Technical Report in preparation.

DAG TJØSTHEIM

Dr. Tjøstheim continued his research in the area of nonlinear models for time series.

1. Some Doubly Stochastic Time Series Models [1]

We consider time series models obtained by replacing the parameters of autoregressive models by stochastic processes. Special attention is given to the problem of finding conditions for stationarity and to the problem of forecasting. For the first problem we are only able to obtain solutions in special cases, and the emphasis is on techniques rather than obtaining the most general results in each case. For the second problem more complete results are obtained by exploiting similarities with discrete time (nonlinear) filtering theory. The methods introduced are illustrated on two standard examples, one of state space type and one where the parameter process is a Markov chain.

2. Recent Developments in Nonlinear Time Series Modelling [2].

We review developments in nonlinear time series that have taken place in the last decade or so. Three main model classes are considered: Models motivated by nonlinear differential equations, bilinear models and doubly stochastic models. For these classes we study problems of existence of a stationary solution, invertibility, prediction, model fitting and quite briefly statistical estimation. We also discuss some attempts of constructing a more general framework for nonlinear time series analysis.

3. Least Squares Estimates and Order Determination Procedures for Autoregressive Processes with a Time Dependent Variance (with J. Paulsen) [3].

We study nonstationary autoregressive processes, where the variance of the generating white noise process is allowed to depend on time. It is shown that ordinary least squares estimates are strongly consistent and with a

proper scaling factor asymptotically normal, but, as can be expected, they are not efficient. Furthermore, AIC type order determination criteria, used as if the underlying process is stationary, are consistent, whereas identification of order in terms of the partial autocorrelation function may lead one astray.

4. Estimation in Nonlinear Time Series Models I: Stationary Series [4].

A general framework for analyzing estimates in nonlinear time series models is developed. Ergodic strictly stationary series are treated. General conditions for strong consistency and asymptotic normality are derived both for conditional least squares and maximum likelihood type estimates. Examples are taken from exponential autoregressive, random coefficient autoregressive and bilinear time series models. Some nonstationary models and examples are treated in a sequel to this paper.

5. Estimation in Nonlinear Time Series Models II: Some Nonstationary Series [5]

In [4] a general framework was introduced for analyzing estimates in stationary nonlinear time series models. Here the framework is enlarged to include certain nonstationary and nonlinear series. General conditions for strong consistency and asymptotic normality are derived both for conditional least squares and maximum likelihood type estimates. Examples are taken from threshold autoregressive, random coefficient autoregressive and doubly stochastic (dynamic state space) models. The emphasis in the examples is on conditional least squares estimates.

References

1. D. Tjøstheim, Some doubly stochastic time series models, Center for Stochastic Processes Technical Report No. 47, November 1983, J. Time Series Anal., to appear.

References (cont'd.)

2. D. Tjøstheim, Recent developments in nonlinear time series modelling, Center for Stochastic Processes Technical Report No. 63, May 1984. The John B. Thomas Volume of Papers on Communications, Networks and Signal Processing, Springer, 1985, to appear.

3. D. Tjøstheim and J. Paulsen, Least squares estimates and order determination procedures for autoregressive processes with a time dependent variance, Center for Stochastic Processes Technical Report No. 64, May 1984. J. Time Series Anal., 1984, to appear.

4. D. Tjøstheim, Estimation in nonlinear time series models I: Stationary Series, Center for Stochastic Processes Technical Report No. 70, July 1984.

5. D. Tjøstheim, Estimation in nonlinear time series Models II: Some Nonstationary Series, Center for Stochastic Processes Technical Report No. 71, July 1984.

RESEARCH IN STATISTICAL ESTIMATION AND INFERENCE

RAYMOND J. CARROLL

During the past year, research has continued in the areas of transformations, heteroscedasticity and related statistical topics. Leonard A. Stefanski and David M. Giltinan completed their Ph.D. dissertations in December, 1983, under the direction of Professor Carroll. Mr. Douglas Simpson and Ms. Marie Davidian are working on their Ph.D. dissertations under the direction of Professor Carroll; Simpson should finish in June 1985, while Davidian has just started her work and should finish in June 1986.

1. Influence and Measurement Error in Logistic Regression. The Ph.D. thesis of Leonard A. Stefanski, supervised by Professor Carroll.

This dissertation concerns the use of logistic regression when certain standard model assumptions are violated. Chapters I and II study the problem of estimating regression parameters when covariates are subject to measurement error. The latter chapters study robust methods applicable to logistic regression.

To facilitate study of the errors-in-variables problem a small measurement error asymptotic theory is developed. This allows comparison of certain estimators which have appeared in the literature and also suggests new estimators which are shown to have better asymptotic properties. A small Monte-Carlo study confirms the superiority of the new estimators in certain settings. In the course of studying the asymptotic behavior of the various estimators interesting use is made of some random convex analysis.

To deal with the problem of messy data, i.e. outliers and extreme covariables, several bounded influence estimators are proposed. The optimality properties of these estimators are studied in Chapter III. Asymptotic theory for the robust procedures is given in Chapter IV. Finally, Chapter V concludes the thesis with an application of these methods to two sets of data.

2. Transformations in Regression: A Robust Analysis (with David Ruppert).

We consider two approaches to robust estimation for the Box-Cox power transformation model. One approach maximizes weighted, modified likelihoods. A second approach bounds the self-standardized gross-error sensitivity, a measure of the potential influence of outliers pioneered by Krasker and Welsch (JASA, 1982).

Among our primary concerns is the performance of these estimators on actual data. In examples that we study, there seem to be only minor differences between these three estimators, but they behave rather differently than the maximum likelihood estimator or estimators that bound only the influence of the residuals.

Confidence limits for the transformation parameter can be obtained by using a large-sample normal approximation or by modified likelihood-ratio testing.

These examples show that model selection, determination of the transformation parameter, and outlier identification are fundamentally interconnected.

3. Bounding Influence and Leverage in Logistic Regression (with L.A. Stefanski and D. Ruppert).

Logistic regression is very sensitive to discordant data. Resistant fitting procedures, though clearly desirable, have not received their due attention. This paper studies two bounded influence estimators similar in spirit to the Krasker-Welsch estimator for linear regression. In motivating the bounded influence procedures some theoretical optimality results for Krasker-Welsch type estimators are obtained. These results are not specific to logistic regression and generalize to other statistical models, in particular the class of generalized linear models. The proposed estimation procedures are illustrated with examples.

4. Bounded Influence Estimation in Heteroscedastic Linear Models. The Ph.D. thesis of David M. Giltinan, supervised by Professor Carroll.

In a heteroscedastic linear model, if there is no replication, the usual approach is to model the variance. A common situation is that where the variance is modelled as a function of the mean response, or of a subset of the explanatory variables. Maximum likelihood estimation of the variance parameter in such models is very sensitive to extreme data points. In this dissertation alternative 'bounded influence' methods are developed which overcome this problem.

The model for the variance which is considered is given by the relationship $\sigma_i = \exp[\underline{h}'(\tau_i)\underline{\theta}]$, where $\underline{h}$ is a known vector-valued function and $\underline{\theta}$ is the unknown variance parameter. Using this model, there is a parallel between the problem of developing efficient bounded influence estimators for $\underline{\theta}$ and that of developing efficient bounded influence estimators for the regression parameter in the homoscedastic regression case. Extension of several such methods of estimating $\underline{\beta}$ to include the problem of estimating $\underline{\theta}$ is discussed.

The method proposed by Krasker (1980) is generalized to include estimation of $\underline{\theta}$ and shown to be optimal in a certain sense. The question of existence of a solution to the estimating equations is discussed.

The methods of Krasker and Welsch (1982) in the homoscedastic regression case are extended to cover estimation of $\underline{\theta}$. A three-stage weighted regression estimate based on these techniques is proposed and the associated influence calculations are presented.

The class of bounded influence regression estimators proposed by Mallows (1975) is considered. A necessary condition for a strongly optimal weight function is derived and the resulting estimator of $\underline{\beta}$ is generalized to obtain an estimator of $\underline{\theta}$. Mallows estimators are shown to possess a stability of

variance which is absent in Krasker-Welsch estimators. A three-stage Mallows regression estimate is proposed and its influence function is given.

Computation of the three-stage estimates is discussed, and the performance of these methods is evaluated by using them in the analysis of a number of data sets.

5. A Note on Levene's Tests for Equality of Variances (with H. Schneider).

Consider testing for equality of variance in a one-way analysis of variance. Levene's test is the usual F-test for equality of mean computed on pseudo-observations, which one defines as the absolute deviations of the data points from an estimate of the group "center". We show that, asymptotically, Levene's test has the correct level whenever the estimate of group "center" is an estimate of group median. This explains why published Monte-Carlo studies have found that Levene's original proposal of centering at the sample mean has the correct level only for symmetric distributions, while centering at the sample median has correct level even for asymmetric distributions. Generalizations are discussed.

6. Some New Estimation Methods For Weighted Regression When There Are Possible Outliers (with D.M. Giltinan and D. Ruppert)

We consider the problem of fitting a linear regression when the data have nonconstant variances, i.e. the problem of heteroscedastic regression. We choose as a model that the variances depend on a function of known predictor variables and unknown parameters. We propose two new estimators which have bounded influence. These estimators are based on the idea of (1) separately bounding all sources of influence, the Mallows approach, and (2) bounding all sources of influence simultaneously, the Hampel and Krasker/Welsch approach. We find that bounding the effect on predicted values gives better estimators in practice

than other methods. The new estimators are evaluated on sets of data which contain outliers.

7. Some Diagnostics for Accelerated Life Testing (with H. Schneider and L. Weissfeld)

In accelerated life testing, we are often concerned with understanding the failure distribution of a component at a fixed level of a predictor variable such as temperature, this level being the one which will be encountered in practice. In many instances it is impractical to do experimentation at the level or temperature of interest, because of time constraints. What is often done in this case is to relate, through a model, failure of a component to the predictor variable. We have encountered situations within the context of accelerated life testing in which one or more components seem to fail much too early. In this paper we describe some simple diagnostics for determining whether single or pairs of points have an enormous impact on the inferences at the level of the predictor variable which is of real interest.

References

1. L.A. Stefanski, Influence and measurement error in logistic regression, Inst. of Statistics Mimeo Series No. 1548, December 1983.

2. R.J. Carroll and D. Ruppert, Transformations in regression: A robust analysis, Inst. of Statistics Mimeo Series No. 1544, March 1984.

3. L.A. Stefanski, R.J. Carroll and D. Ruppert, Bounding influence and leverage in logistic regression, Inst. of Statistics Mimeo Series No. 1554, August 1984.

4. D.M. Giltinan, Bounded influence estimation in heteroscedastic linear models, Inst. of Statistics Mimeo Series No. 1547, December 1983.

5. R.J. Carroll and H. Schneider, A note on Levene's tests for equality of variances, Inst. of Statistics Mimeo Series No. 1553, July 1984.

6. R.J. Carroll, D.M. Giltinan and D. Ruppert, Some new estimation methods for weighted regression when there are possible outliers, Inst. of Statistics Mimeo Series, in preparation.

7. R.J. Carroll, H. Schneider and L. Weissfeld, Some diagnostics for accelerated life testing, Inst. of Statistics Mimeo Series, in preparation.

HELMUT SCHNEIDER

Dr. Schneider visited during the 1983-84 academic year and conducted research in the following areas:

1. A numberical analysis of sampling plans based on prior distribution and costs

This paper deals with some pitfalls linked with the sampling model based on prior distribution and costs. First, a model is designed which encompasses most of the existing Bayesian cost models. The efficiency of sampling plans is investigated in a numerical study. It is shown that under realistic assumptions, described by Dodge (1969) and Schilling (1982), sampling plans based on prior distributions and costs are only efficient in an outlier model, i.e. if almost all lots are of good quality and only a low number of lots, denoted as outlier lots, have very poor quality. Furthermore, it is demonstrated that for the Polya distribution a gain of sampling is linked with a high percentage of rejections, i.e. when the prior distribution cost relationship is such that less than 5% of the lots should be rejected,sampling becomes inefficient.

2. The Performance of Variable Sampling Plans when the Normal Distribution is Truncated.

The robustness of standard variable sampling plans by Lieberman and Resnikoff is considered with respect to a truncation of the normal distribution. It is shown how variable sampling plans can be designed if the truncation point and σ^2 are known.

3. Analysis of a Multi-Item Inventory Problem Using Optimal Policy Surfaces

An interactive algorithm is presented which allows the selection of a combination of service-level, investment, workload and storage room which is "appropriate" for the management. This method produces combinations which lie on an optimal surface.

Since in our method there are some approximations involved, we prove the validity of the approximation formulas by means of a Monte Carlo study in the final section.

4. The EM Algorithm for Censored Data (with Lisa Weissfeld)

Three methods for applying the EM algorithm to censored data are considered, the Buckley-James (1979), a proposed simpler nonparametric method and a normal model for censored data. A new estimator for the variance of y in the Buckley-James model is proposed and simulations comparing the three methods are described. To illustrate the use of these methods they are applied to the Stanford heart transplant data.

References

1. H. Schneider, A numerical analysis of sampling plans based on prior distribution and costs, Inst. of Statistics Mimeo Series No. 1558, September 1984.

2. H. Schneider, The performance of variable sampling plans when the normal distribution is truncated, Inst. of Statistics Mimeo Series No. 1559, September 1984.

3. H. Schneider, Analysis of a multi-item inventory problem using optimal policy surfaces, Inst. of Statistics Mimeo Series No. 1556, August 1984.

4. H. Schneider and L. Weissfeld, The EM algorithm for censored data, Inst. of Statistics Mimeo Series No. 1557, June 1984.

PUBLICATIONS

"Interpreting multiple logistic regression coefficients in prospective observational studies.", R.D. Abbott and R.J. Carroll, Amer. J. Epidemiology, 119, 1984, 830-836.

"Similarities and contrasts between Gaussian and other stable signals." S. Cambanis, Fifth Aachen Colloquium on Mathematical Methods in Signal Processing, Sept. 26-29, 1984, 113-120.

"Prediction of stable processes: Spectral and moving average representations." S. Cambanis and A. Soltani, Z. Wahrsch. verw. Geb., 66, 1984, 593-612.

"Comparisons between maximum likelihood and method of moments in a linear errors-in-variables regression model." R.J. Carroll and P.P. Gallo, Design of Experiments: Ranking and Selection, T.J. Santner and A.c. Tamhane, eds., Marcel Dekker, 1984.

"Discussion of Hinkley and Runger's paper "The Analysis of Transformed Data." R.J. Carroll and D. Ruppert, J. Amer. Statist. Assoc., 71, 1984, 312-313.

"Power transformations when fitting theoretical models to data." R.J. Carroll and D. Ruppert, J. Amer. Statist. Assoc., 71, 1984, 321-329.

"On errors-in-variables for binary regression models." R.J. Carroll, C. Spiegelman and R.D. Abbott, Biometrika, 71, 1984, 19-26.

"Limit laws for the maximum of weighted and shifted i.i.d. random variables." D. Daley and P. Hall, Ann. Probability, 12, 1984, 571-587.

"Uniform consistency of a class of regression function estimators." W. Haerdle and S. Luckhaus, Ann. Statist., 12, 1984, 612-623.

"A law of the iterated logarithm for nonparametrix regression function estimators." W. Haerdle, Ann. Statist., 12, 624-635.

"Generalized Feynman integrals using analytic continuation in several complex variables." G. Kallianpur and C. Bromley, Stochastic Analysis and Applications, M. Pinsky, ed., Marcel Dekker, 1984.

"Some recent developments in nonlinear filtering theory." G. Kallianpur and R.L. Karandikar, July 83. Acta Appl. Math., 1, 1984, 249-284.

"Measure-valued equations for the optimum filter in finitely additive nonlinear filtering theory." G. Kallianpur and R.L. Karandikar, Z. Wahrsch. verw. Geb., 66, 1984, 1-17.

"The nonlinear filtering problem for the unbounded case." G. Kallianpur and R.L. Karandikar, Stochastic Proc. Appl., 18, 1984, 57-66.

"Extremes and local dependence in stationary sequences." M. Leadbetter, Z. Wahrsch. verw. Geb., 65, 1984, 291-306.

"Spectral density estimation for stationary stable processes." E. Masry and S. Cambanis, Stochastic Proc. Appl., 18, 1984, 1-31.

"A conditional limit law result for jumps in the sequence of partial maxima of a stationary Gaussian process." W.P. McCormick, Sankhya, Ser. A, 45, 1983, 191-200.

"Consistency in least squares estimation: a Bayesian approach." H. Rootzén and J. Sternby, Automatica, 20, 1984, 471-475.

"Attainable rates of convergence of maxima." H. Rootzén, Statist. Probability Letters, 2, 1984, 219-221.

"Extrapolation and moving average representation for stationary random fields and Beurling's theorem." A. Soltani, Ann. Probability, 12, 1984, 120-132.

"Decomposability of p-cylindrical martingales." Z. Suchanecki and A. Weron, Math. Z., 185, 1984, 271-280.

"Stable processes and measures: A survey." A. Weron, Probability Theory on Vector Spaces III.", D. Szynol and A. Weron, eds., Lecture notes in Math. Vol. 1080, Springer, 1984, 306-364.

TO APPEAR AFTER SEPT. 1, 1984

"Sampling designs for time series." S. Cambanis, Handbook of Statistics, Volume 5: Time Series in Time Domain, E.J. Hannan, P.R. Krishnaiah and M.M. Rao, eds., North Holland, 1984, to appear.

"Convergence of quadratic forms in p-stable random variables and p-radonifying operators." S. Cambanis, J. Rosinski, and W. Woyczynski, Ann. Probability, 1985, to appear.

"A note on N-estimators for the binomial distribution. R.J. Carroll and F. Lombard, J. Amer. Statist. Assoc., 1984, to appear.

"Transformations in regression: A robust analysis." R.J. Carroll and D. Ruppert, Technometrics, 1984, to appear.

"A lower bound for mean characteristics in $E_kG/1$ and $GI/E_k/1$ queues." D.J. Daley, Math. Operationsforschung Statist., 1985, to appear.

"Tail estimates motivated by extreme value theory." R. Davis and S. Resnick, Ann. Statist., 12, 1984, to appear.

"A spectral representation for max-stable processes." L. de Haan, July 82. Ann. Probability, 12, 1984, to appear.

"Approximations to the mean integrated squares error with applications to optimal bandwidth selection for nonparametric regression function estimators." W. Haerdle, J. Multivariate Anal., 1985, to appear.

"Recent developments in probabilistic geotechnical engineering." A.M. Hasofer, Symp. on Recent Developments in Laboratory and Field Tests and Analysis of Geotechnical Problems, Balkema Publ., Rotterdam, 1984, to appear.

"A finitely additive white noise approach to nonlinear filtering: A brief survey." G. Kallianpur and R.L. Karandikar, Proc. 6th Int. Symp. on Multivariate Anal., 1984, to appear.

"The Markov property of the filter in the finitely additive white noise approach to nonlinear filtering." G. Kallianpur and R.L. Karandikar, Stochastic Proc. Appl., 1984, to appear.

"Regularity property of Donsker's delta function." G. Kallianpur and H.H. Kuo, Appl. Math. Optimization, 1984, to appear.

"Infinite dimensional stochastic differential equation models for spatially distributed neurons." G. Kallianpur and R. Wolpert, Appl. Math. Optimization, 1984, to appear.

"Maximum likelihood estimation in the multiplicative intensity model." A. Karr, Ann. Statist., 13, 1985, to appear.

"Extremes in dependent random sequences." M.R. Leadbetter, Statistical Extremes and Applications, Proc. NATO-ASI, J.T. de Oliveira, ed., Reidel, 1984, to appear.

"An iterated logarithm law result for extreme values from Gaussian sequences." W.P. McCormick, J. Appl. Probability, 1984, to appear.

"Weak and strong law results for a function of the spacings." W.P. McCormick, J. Appl. Probability, 1984, to appear.

"On Minimality and interpolation of harmonizable stable processes." M. Pourahmadi, SIAM J. Appl. Math., 44, 1984, 1023-1030.

"Least squares estimates and order determination procedures for autoregressive processes with a time dependent variance." J. Paulsen and D. Tjostheim, J. Time Series Anal., 1984, to appear.

"Moment inequalities for p-stable stochastic integrals." J. Rosinski and W.A. Woyczynski, Lecture Notes in Mathematics, Springer, 1985, to appear.

"Extremes in continuous stochastic processes." H. Rootzén, Statistical Extremes and Applications, Proc. NATO-ASI, J.T. de Oliveira, ed., Reidel, 1984, to appear.

"Monte-Carlo optimization by stochastic approximation, with application to harvesting of Atlantic menhaden.", D. Ruppert, R.L. Reish, R.B. Deriso and R.J. Carroll, Biometrics, 1984, to appear.

"A stochastic model for managing the Atlantic menhaden fisher and assessing managerial risks." D. Ruppert, R.L. Reish, R.B. Deriso and R.J. Carroll, Can. J. Fisheries., 1984, to appear.

"An asymptotic theory for logistic regression when some variables are measured with error. L.A. Stefanski and R.J. Carroll, Ann. Statist., 1985, to appear.

"Recent developments in nonlinear time series modelling." D. Tjostheim, The John B. Thomas Volume of Papers on Communication, Networks and Signal Processing, Springer, 1985, to appear.

"Some doubly stochastic time series models." D. Tjostheim, J. Time Series Anal., to appear.

"Harmonizable stable processes on groups: Spectral, ergodic and interpolation properties." A. Weron, Z. Wahrsch. verw. Geb., 1984, to appear.

CENTER FOR STOCHASTIC PROCESSES TECHNICAL REPORTS

42. "A finitely additive white noise approach to nonlinear filtering: A brief survey." G. Kallianpur and R.L. Karandikar, Nov. 83. Proc. 6th Int. Symp. on Multivariate Anal., to appear.

43. "A certain class of diffusion processes associated with nonlinear parabolic equations." T. Funaki, Nov. 83.

44. "The Markov property of the filter in the finitely additive white noise approach to nonlinear filtering." G. Kallianpur and R.L. Karandikar, Nov. 83. Stochastic Proc. Appl., 1984, to appear.

45. "A linear filtering problem using Radon transform." S. Takenaka, Oct. 83.

46. "Maximum likelihood estimation in the multiplicative intensity model." A. Karr, Nov. 83. Ann. Statist., 13, 1985, to appear.

47. "Some doubly stochastic time series models." D. Tjostheim, Nov. 83. J. Time Series Anal., to appear.

48. "Consistency in least squares estimation: A Bayesian approach." H. Rootzen and J. Sternby, Nov. 83. Automatica, 20, 1984, 471-475.

49. "Weak convergence of semimartingales." M. Metivier, Nov. 83.

50. "On smoothed probability density estimation for stationary sequences." J. Castellana and M.R. Leadbetter, Dec. 83.

51. "Regularity property of Donsker's delta function." G. Kallianpur and H.H. Kuo, Dec. 83. Appl. Math. Optimization, 1984, to appear.

52. "The diffusion approximation of the spatially homogeneous Boltzmann equation." T. Funaki, Dec. 83.

53. "Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces, and a Cameron-Martin formula." G. Kallianpur, D. Kannan, and R.L. Karandikar, Dec. 83.

54. "Tail estimates motivated by extreme value theory." R. Davis and S. Resnick, Jan. 84. Ann. Statist., 12, 1984, to appear.

55. On minimality and interpolation of harmonizable stable processes." M. Pourahmadi, Jan. 84. SIAM J. Appl. Math., 44, 1984, 1023-1030.

56. "The symmetry group and exponents of operator stable probability measures." W. N. Hudson, Z. J. Jurek and J. Veeh, Feb. 84.

57. "Cooptional times and invariant measures for transient Markov chains." M. Jacobsen, Feb. 84.

58. "Sampling designs for time series." S. Cambanis, Feb. 84. Handbook of Statistics, Volume 5: Time Series in Time Domain, E.J. Hannan, P.R. Krishnaiah and M.M. Rao, eds., North Holland, 1984, to appear.

59. "Ergodic properties of stationary stable processes." S. Cambanis, C.D. Hardin, and A. Weron, Mar. 84.

60. "Weak convergence of solutions of stochastic differential equations with applications to nonlinear neuronal models." G. Kallianpur and R. Wolpert, Mar. 84.

61. "On stationarity of the solution of a doubly stochastic model." M. Pourahmadi, April 84.

62. "A lower bound for mean characteristics in $E_k G/1$ and $GI/E_k/1$ queues." D.J. Daley, May, 84.Math. Operationsforschung Statist., 1985, to appear.

63. "Recent developments in nonlinear time series modelling." D. Tjostheim, May 84. The John B. Thomas Volume of Papers on Communications, Networks and Signal Processing, Springer, 1985, to appear.

64. "Least squares estimates and order determination procedures for autoregressive processes with a time dependent variance." J. Paulsen and D. Tjostheim, May 84. J. Time Series Anal., 1984, to appear.

65. "Stable processes and measures: a survey." A. Weron, June 84. Probability Theory on Vector Spaces III, D. Szynol and A. Weron, eds., Lecture notes in Math. Vol. 1080, Springer, 1984, 306-364.

66. "Rényi's representation, extremal process and an autoregressive process." L. de Haan, June 84.

67. "White noise calculus and nonlinear filtering theory." G. Kallianpur and R.L. Karandikar, June 84.

68. "Limit theory for the sample covariance and correlation functions of moving averages." R. Davis and S. Resnick, July 84.

69. "On the rate of mean convergence of finite linear predictors of multivariate stationary stochastic processes." M. Pourahmadi, July 84.

70. "Estimation in nonlinear time series models I: Stationary series." D. Tjostheim, July 84.

71. "Estimation in nonlinear time series Models II: Some nonstationary series." D. Tjostheim, July 84.

72. "More limit theory for the sample correlation function of moving averages." R. Davis and S. Resnick, Aug. 84.

73. "A non-commutative quasi subadditive ergodic theorem." R. Jajte, Aug. 84.

74. "Limiting distributions of functionals of Markov chains." R.L. Karandikar and V.G. Kulkarni,. Aug. 84.

75. "Infinite order autoregressive representations of multivariate stationary stochastic processes." M. Pourahmadi, Sept. 84.

76. "On the probability generating functional for point processes." D.J. Daley and D. Vere-Jones, Sept. 84.

77. "Local dependence and point processes of exceedances in stationary sequences." J. Husler, Sept. 84.

78. "A note on the prediction error for small time lags into the future." J.A. Bucklew, Sept. 84.

79. "Skewed stable variables and processes." C.D. Hardin, Sept. 84.

80. "The asymptotic behavior of the likelihood ratio statistic for testing a shift in mean in a sequence of independent normal variates." Y.C. Yao and R.A. Davis, Sept. 84.

IN PREPARATION

J.A. Bucklew and S. Cambanis, Sampling designs for estimating random integrals with observation noise.

S. Cambanis, C.D. Hardin and A. Weron, Wold decompositions of symmetric stable sequences.

S. Cambanis and E. Masry, Performance of discrete-time predictors of continuous-time processes.

T. Hsing, Point processes associated with extremes of stochastic sequences.

T. Hsing and M.R. Leadbetter, Limit theorems for high level exceedances by stationary sequences.

W.N. Hudson, Stochastic integrals with respect to independent increment processes.

Z. Jurek and J. Rosinski, Continuity of some random integral mappings.

G. Kallianpur and H.H. Kuo, Applications of differential geometry in statistical processes.

H. Korezlioglu and C. Martias, Stochastic integration for operator-valued processes on Hilbert spaces and on nuclear spaces.

H. Korezlioglu, An approximation for the Zakai equation by a finite difference equation.

M.R. Leadbetter and H. Rootzén, Extremal theory - a point process approach.

H.O. Niemi, Prediction properties of stationary random fields on Z^2.

J. Rosinski, Stochastic integral representation of stable processes with sample paths in Banach spaces.

J. Rosinski and W.A. Woyczynski, Moment inequalities for p-stable stochastic integrals.

INSTITUTE OF STATISTICS MIMEO SERIES TECHNICAL REPORTS

1544. Transformations in regression: A robust analysis, R.J. Carroll and D. Ruppert, March 1984.

1547. Bounded influence estimation in heteroscedastic linear models, D.M. Giltinan, December 1983.

1548. Influence and measurement error in logistic regression, L.A. Stefanski, December 1983.

1553. A note on Levene's tests for equality of variances, R.J. Carroll and H. Schneider, July 1984.

1554. Bounding influence and leverage in logistic regression, L.A. Stefanski, R.J. Carroll and D. Ruppert, August 1984.

1556. Analysis of a multi-item inventory problem usign optimal policy surfaces, H. Schneider, August 1984.

1557. The EM algorithm for censored data, H. Schneider and L. Weissfeld, June 1984.

1558. A numerical analysis of sampling plans based on prior distribution and costs, H. Schneider, September 1984.

1559. The performance of variable sampling plans when the normal distribution is truncated, H. Schneider, September 1984.

IN PREPARATION

Some new estimation methods for weighted regression when there are possible outliers, R.J. Carroll, D.M. Giltinan and D. Ruppert.

Some diagnostics for accelerated life testing, R.J. Carroll, H. Schneider and L. Weissfeld.

STOCHASTIC PROCESSES SEMINARS

Nov. 2	Inference for point processes, Alan F. Karr, John Hopkins University and Univ. of North Carolina.
Nov. 14	Estimation of a square summable mean, James Pickands, III, University of Pennsylvania.
Nov. 16	Extremes of moving average processes, Holger Rootzen, Univ. of Copenhagen and Univ. of North Carolina.
Dec. 7	Martingale inference for point processes, Alan F. Karr, John Hopkins University and Univ. of North Carolina.
Jan. 18	Feynman integrals and a Cameron-Martin formula, G. Kallianpur, Univ. of North Carolina.
Jan. 23	Stochastic differential equation models for the behavior of neurons, G. Kallianpur, Univ. of North Carolina.
Jan. 25 Feb. 1	Stochastic differential equations for spatially distributed neurons, Robert Wolpert, Duke University.
Feb. 8	Probabilistic approach to the Boltzmann equation, T. Funaki, Nagoya Univ. and Univ. of North Carolina.
Feb. 15	Operator stable laws, William Hudson, Auburn Univ. and Univ. of North Carolina.
Feb. 22	A white noise approach to stochastic integration, H.H. Kuo, Louisiana State University and Univ. of North Carolina.
Feb. 29	Stable processes and stochastic integrals, Jan Rosinski, Case Western Reserve University.
Mar. 28	Ergodic properties of stationary stable processes, Stamatis Cambanis, University of North Carolina.
April 4	Multidimensional quantization, J.A. Bucklew, Univ. of Wisconsin and Univ. of North Carolina.
April 11	Limit theory for moving averages, Richard Davis, Colorado State Univ. and Univ. of North Carolina.
April 25	Extreme values for stationary and Markov sequences, George O'Brien, York Univ. and Cornell Univ.
May 2 May 10	Markov random fields and the Bayesian restoration of images, Donald Geman, University of Massachusetts.

May 8	Fluctuation phenomena for interacting diffusions, Masayuki Hitsuda, Kumomoto University, Japan.
May 14	Inequalities in probability theory, D.J. Daley, Australian National Univ.
May 18	Selfdecomposable probability measures, Zbigniew J. Jurek, University of Utah.
June 4	Estimation in nonlinear time series models, Dag Tjostheim, Univ. of Bergen and Univ. of North Carolina.
June 6	Asymptotic representation results for products of random matrices, C.C. Heyde, University of Melbourne.
July 30	Infinite autoregressive representation of multivariate stationary stochastic processes, Mohsen Pourahmadi, Northern Illinois Univ. and Univ. of North Carolina.
Aug. 1	Tail behaviour for the suprema of empirical processes, Robert J. Adler, Technion.
Aug. 7	A brief survey of some problems in stochastic analysis, M.P. Heble, University of Toronto.
Aug. 15	The characteristic functional of a probability measure absolutely continuous with respect to a Gaussian random measure, Hiroshi Sato, Kyushu University, Japan.
Aug. 22	Mutual information in stationary channels, Shunsuke Ihara, Ehime University, Japan.

LIST OF PROFESSIONAL PERSONNEL

1. Faculty Investigators:

S. Cambanis
R.J. Carroll
G. Kallianpur
M.R. Leadbetter

2. Visitors

Senior

D.Daley	Australian National Univ.	May 84
L. de Haan	Erasmus Univ.	May - July 84
W. Hudson	Auburn Univ.	Jan. - Aug. 84
R. Jajte	Lodz Univ.	July 84 - present
A.F. Karr	Johns Hopkins Univ.	Nov. - Dec. 83
A.H. Korezlioglu	E.N.S. Telecommunications	Aug. 84 - present
H.H. Kuo	Louisiana State Univ.	Feb. 84
H. Niemi	Univ. of Helsinki	Aug. 84 - present
H. Rootzén	Univ. of Copenhagen	Nov. - Dec. 83
D. Tjostheim	Univ. of Bergen	Nov. 83 - July 84

Junior:

J.A. Bucklew	Univ. of Wisconsin	Jan. - May 84
R. Davis	Colorado State Univ.	Jan. - June 84
T. Funaki	Nagoya Univ.	Nov. 83 - May 84
R. Karandikar	Indian Statistical Institute	Jan. - July 84
M. Pourahmadi	Northern Illinois Univ.	Jan. - July 84
J. Rosinski	Case Western Reserve Univ.	July 84 - present
H. Schneider	Free Univ. of Berlin	Jan. - June 84

3. Graduate Students:

S.K. Christensen
M. Davidian
D. Giltinan
H.P. Hucke
T. Hsing
M.S. Marques
V. Perez-Abreu
L.A. Stefanski

INTERACTIONS

S. Cambanis gave colloquium talks at the University of Tennessee in Knoxville (Feb. 84), Louisiana State University (April 84) and University of Thessaloniki (June 84), and an invited talk at the Conference on Stochastic Processes and Their Applications held at Gothenberg, Sweden (June 84). He served as associate editor of the IEEE Transactions on Information Theory and the SIAM Journal on Applied Mathematics.

R.J. Carroll presented invited talks at the University of Wisconsin (Nov. 83); Princeton University (April 84); the National Bureau of Standards (April 84); the Midwest Biopharmaceutical Workshop (June 84); the University of Heidelberg (June 84); the Swiss Federal Institute of Technology (July 84); the U.S. Bureau of the Census (Aug. 84). He organized a session on robustness and diagnostics at the annual meeting of the American Statistical Association. Throughout the year he served as an associate editor for the Journal of the American Statistical Association and the Annals of Statistics, as well as a member of a National Academy of Sciences panel on Youth Employment in the United States.

G. Kallianpur gave an invited lecture at the I.F.I.P. Conference on Stochastic Differential Systems & Filtering at Luminy-Marseilles France, (March 84), and a series of talks on nonlinear filtering and stochastic differential equations at the Department of Mathematics, University of Alberta, Edmonton, Alberta, Canada (April 84). He also served as editor of Sankhya and as associate editor of the Journal of Multivariate Analysis, the Journal of Applied Mathematics and Optimization, and Stochastic Processes and Their Applications.

M.R. Leadbetter gave invited talks at the Oberwolfach conference on order statistics and quantiles (April 84) and at the annual Conference on Stochastic Processes and Their Applications held at Gothenberg, Sweden (June 84). He continued his activity on the Council for the Institute of Mathematical

Statistics, and represented the IMS on the American Mathematical Society committe for summer conferences.

T. Funaki gave colloquium talks at Rutgers University and New York University.

W. Hudson gave a talk at the Conference on Probability on Banach Spaces held at Tufts University in Boston (July 84).

R. Karandikar gave colloquium talks at Michigan State University and at the Operations Research Department of the University of North Carolina.

M. Pourahmadi attended the NSF Conference on Inference for Stochastic Processes held at Lexington, KY (May 84).

H. Rootzén gave colloquia at Colorado State University and at Johns Hopkins University.

J. Rosinski gave a talk at the Conference on Probability on Banach Spaces held at Tufts University in Boston (July 84).

H. Schneider presented seminars at McMaster University, the University of Calgary and the University of North Carolina at Chapel Hill.

D. Tjøstheim gave a talk at the Princeton Conference on Information Sciences and Systems held at Princeton University (March 84).

A. Weron gave a talk at the Conference on Probability on Banach Spaces held at Tufts University in Boston (July 84).

END

FILMED

1-85

DTIC